On the variability of Indonesian large species of *Tectarius* Valenciennes, 1832 from Java, Indonesia (Gastropoda, Littorinidae) with the description of new species

Variabilitas spesies *Tectarius* Valenciennes, 1832 berukuran besar dari Jawa, Indonesia (Gastropoda, Littorinidae) dengan deskripsi spesies baru

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Abstract

The variability of Tectarius pagodus (Linnaeus, 1758) is reviewed. Based on morphological differences, a new species is described as Tectarius padmiae sp. nov. from southern Java and comments are made on the synonyms of T. pagodus. The new species has 14-16 knobs/spines on the body whorl while T. pagodus usually only has 9-12 knobs/spines. A further important difference is that the new species has the knobs on 3 spiral lines instead of 2 and that they are axially strongly wavy. The new species is also compared with the much smaller T. tectumpersicum (Linnaeus, 1758) and T. grandinatus (Gmelin, 1791).

Abstrak

Variabilitas *Tectarius pagodus* (Linnaeus, 1758) diulas dalam makalah ini. Berdasarkan perbedaan morfologi, satu spesies dari selatan Jawa dipertelakan dengan nama *Tectarius padmiae* sp. nov. dengan pemberian komentar terhadap nama-nama sinonim dari *T. pagodus.* Jenis baru ini mempunyai 14-16 duri pada seluk badan dimana *T. pagodus* biasanya hanya mempunyai 9-12 duri. Perbedaan lebih jauh yang cukup penting adalah jenis baru ini mempunyai 3 baris spiral berduri, bukan 2 seperti umumnya dijumpai pada *T. pagodus,* dan duri-duri ini membentuk barisan yang bergelombang secara aksial. Jenis baru ini dibandingkan pula dengan jenis yang lebih kecil *T. tectumpersicum* (Linnaeus, 1758) dan *T. grandinatus* (Gmelin, 1791).

Keywords: *Littorinidae, Tectarius, pagodus,* Indonesia, taxonomy, new species

Introduction

New species from Indonesia should be expected to turn out every year if properly researched but the deep water dredging of the Paris Museum led by Prof. Phillipe Bouchet focus on countries with French affinities like New Caledonia where permits for the research can be obtained by the French researchers. The diversity of molluscan life in the waters of Indonesia must be high with the thousands of islands and many different habitats in a tropical setting being part of the so called Coral Triangle. Also hundreds of new species are described from the close by Philippines islands in the north of Indonesia, a strong hint that Indonesian waters should have its fair share of (new) species. Indonesia is a Miocene hotspot for mollusks and should be accepted as such in the recent, awaiting more research but who knows when that will be organized. Williams et al (2003) made a molecular research on the living Littorinidae. The genus *Tectarius* Valenciennes, 1832 (eleven recent species) was believed to be monophyletic though not all species were sampled. The most recent addition to the genus was *T. niuensis* Reid & Geller, 1997 from Niue in the South Pacific. The largest species of the genus is without doubt *T. pagodus* (Linnaeus, 1758). The species is described in the 10th edition and Linnaeus refers to Argenville, plate 11 fig. A "Pagodus". O Asiatico. Roosewater (1972) restricted the type locality to Amboina, Moluccas (= present day Ambon, Indonesia). According to Roosewater the figure of Argenville is the 'lectotype figure'. A synonym is *Monodonta bicolor* Lamarck, 1822. Rosewater provides a b/w photo of the (holo)type held in MHNG.

The second author accompanied by his wife found examples of a large *Tectarius* species on the rocky and sandy beach in the south of Java (Indian Ocean side of Java) looking like *T. pagodus* but which were different in ornamentation and of a real large size for the species, up to almost 70 mm. The first author was consulted and we started a search for the large Tectarius and literature. Clear morphological differences with *T. pagodus* and the odd location (Indian Ocean) compared to the West Pacific range of *T. pagodus* made us decide to describe these found shells as a new species.

Abbreviations:

AMD: Collection of A.M. Dekkers, Blokker, the Netherlands
ARN: Collection of Armen Rizal Ngo, Jakarta, Indonesia
MZB: Museum Zoologicum Bogoriense, Bogor, West Java, Indonesia
NBC Naturalis: Naturalis Biodiversity Center, Leiden, The Netherlands
RMNH.MOL: Collection number of shells in NBC Naturalis, former Rijksmuseum voor Natuur Historie, Leiden, The Neterlands
ZMA.MOLL: Collection number of shells in the former Zoölogisch Museum Amsterdam, the Netherlands (now closed, now in NBC Naturalis collection).

H: height of the shell
W: width of the shell without spines
LA: apertural length
WA: apertural width

Material and Methods

The materials used in this paper were collected by the second author and compared to specimens from NBC and private collection. The literature was searched for records and images of *Tectarius pagodus* and synonyms. Available materials were compared and checked against the original descriptions. The new species descriptions are based on all the examined specimens. The characters used to describe the shell morphology are the general aspect of the shell, color, ornamentation, its shape and size. Also shell proportion (H/W), apertural shape (WA/LA), and relative spire height (H/

LA) are used in the study but not reflected in the descriptions. These measurements of shell height and width were preferred to those parallel and perpendicular to the axis of coiling. Apertural length (LA) was measured as the maximum external dimension, and apertural width (WA) was measured as the maximum external dimension perpendicular to LA (Reid, 1984). All width measurements are taken with the spines excluded.

Systematics

Order: Littorinimorpha Golikov & Starobogatov, 1975
Superfamily: Littorinoidea Children, 1834
Family: Littorinidae Children, 1834
Subfamily: Littorininae Children, 1834
The subfamily Tectariinae Rosewater, 1972 accepted as Littorininae Children, 1834.
Genus: *Tectarius* Valenciennes, 1832
Type species: *Tectarius coronatus* Valenciennes, 1832 (type by monotypy).

Original description (of subgenus *Tectarius* sensu stricto): Moderately large, pyramidal to turbinate, non-umbilicate littorinids with from rather strongly spinose to nodulose or papillose shells; generally living at or above high tide line. Radula littorinoid, the central tooth somewhat narrowed, the lateral tooth with an embayment and usually developing a medial vertical ridge or partition. In males the penis is large and well-supplied with glands along most of its lateral edge, the remainder papillose, and with an open but deeply folded seminal duct. Operculum rounded, mesospiral. Aperture plicate within; with a columellar swelling or tooth.

Synonyms of the genus: *Echinellopsis* Rovereto, 1899, *Pagodella* Swainson, 1840, *Pagodus* Gray, 1839.

Tectarius padmiae sp. nov.

http://zoobank.org/2643B7DD-3A99-42F7-BBCA-552B733A598A

Type material

Holotype: MZB Gst. 22015, H 69.5 mm, W 54 mm, Malang, South of Java, Indonesia. Paratypes: all from the type locality: Paratype 1 NBC Naturalis RMNH.MOL.347604 H 68 mm W 51.3 mm; Paratype 2 ARN H 66 mm W 51.5 mm; Paratype 3 ARN H 68.5 mm W 51.5 mm; Paratype 4 AMD H 69,5 mm W 51.8 mm.

Type locality

Malang, South of Java, Indonesia (Indian Ocean).

Description

Shell very solid, reaching 70 mm in height, neatly conical in shape, mature individuals rather heavily constructed, broad individuals with visible but very tight umbilicus, and sculptured on the body whorl (last half turn) with 3 rows of usually thick, straightly projecting or slightly upturned spines, thrown into oblique axially (following the corner of the aperture) waves. Overall external color dull yellowish, with no discernible pattern.

Base distinctly not flattened but concave, sculptured spirally with nodulose cords which are extending over the body whorl; base not separated from upper part of body whorl. More than 5 whorls, but cannot be counted in total because of the worn apexes in the type specimens. Body whorl rounded, pre-ultimate whorl and the spire whorls little convex, produced at an angle, and looking angular at the shoulder caused by a single row of spines. Length of spire usually half the length of shell. Aperture broadly rounded; outer lip not extra thickened in mature individuals, strongly plicate within (ca. 18); plicae not reaching edge of aperture; inner lip not smooth but crenulated by the ending of the spiral ribbing. Columella smooth with exception of a tiny bulge half way.

Suture well visible. Outstanding sculptural feature is the mid whorl spinose carina on the spire whorls, the pre-ultimate whorl with typically from 9-12 regular spirally flattened spines on the shoulder. On the body whorl the about 10 ditto spirally flattened spines, that gradually become roof-like and cropped for the last 5-6 spines towards the aperture (in total about 14-16). Operculum not present in the empty found shells, but likely not differing from the ones found on living *T. pagodus*. Animal not studied.

Habitat

The type material was dead collected, beached in a small bay surrounded by vertical limestone cliffs. The beach consisted of coarse sand, pebbles, rocky outcrops. Although they were found sympatrically with *Tectarius pagodus*, they appear to live on the lower level of littoral zone than *T. pagodus*. As the shells were encrusted with some kind of coral growth on the older whorls, the suggestion is that they live on strongly wave-exposed rocky substrate.

Distribution

Thus far only known from the type locality, but can be expected to live in a broader range south of Java.

Etymology

Named in honour of the second author's wife, Padmi Aryani. The name is derived from Sanskrit but also a Javanese word for "queen consort".

Variability

The new species is rather constant in form, morphology and colour. But we have a more slender form in our collections without collecting details. This more slender form is also present in the NBC Naturalis collection (only one specimen in lot ZMA. MOLL.320198) but we and curator Jeroen Goud have our doubts if this shell is originally contained in the lot with *T. pagodus* or added to it, by the collector or in the past by museum collaborators. This particular specimen might be a freak (Figure 1 – J).

Comparison and remarks

The new species is most similar to the rather variable *Tectarius pagodus* (Linnaeus, 1758) which is of a slightly less large size but broader. *Tectarius pagodus* coming from the Pacific side of the Indonesian islands have a 'crown' on the shoulder on the spire whorls of connected upturned spirally flattened spines. The species has 2 rows of flattish spirally aligned knobs (11-12) on the body whorl with many secondary almost scaly spiral threads in between the 2 spiral lines and above to the suture. Also we have never encountered an umbilicate *T. pagodus*. *Tectarius pagodus* is rather variable, partly explained by the variable morphological features during the growth phases (Figure 2).

Tectarius tectumpersicum (Linnaeus, 1758) also living in Indonesian waters (Dharma 2005: 94, plate 22, sp. 18a-c) is grossly similar in many ways to *T. padmiae* sp. nov. and of course there is a big difference in size; *T. padmiae* reaches a height of 70 mm while *T. tectumpersicum* rarely reaches around 35 mm. Differences are apparent also in spinosity, though both species have 3 rows of spines on the body whorl. Spines in *T. tectumpersicum* tend to be stubby and ending roundish and upturned while in *T. padmiae* they are broadly triangular in the spiral arrangement and in the end towards the aperture the 5 rows are becoming roof-tile like. There is seldom any difficulty in separating these 2 species with comparative material at hand.

Tectarius grandinatus (Gmelin, 1791) is endemic to the Cook islands, far away in the Western Pacific from the south of Java (type locality of the new species). It is also rather large (up to about 38 mm) but clearly less in size, and also uniformly coloured kind of dull yellow. This species however has more spiral bands, 4 on the pre-ultimate whorl and 7 on the body whorl gradually becoming spirals on the base of the shell (6 more spirals), all with upturned knobby spines.

Tectarius coronatus Valenciennes, 1832 also living in Indonesian waters (Dharma 2005: 94, plate 22, sp. 17a-b as *T. rugosus*) is almost impossible to confuse with the new species by its much smaller size (up to 28-30 mm), 4 rows of neat knobs on the body whorl and above that usually colour bands that all other species lack.

Tectarius rusticus (Philippi, 1846) is a north-western Australian species that can reach a moderate size of about 37 mm. These shells have often only shallow spiral lines, but also shells with small pointed knobs occur. Uniformly coloured, dull greyish to yellowish. Cannot be confused with the new species.

Studied material

Tectarius tectumpersicum: AMD 2x New Guinea, H 31 mmm and H 37 mm and 2 juveniles from the same lot; seen but not measured, all form Indonesia (except 1, from the Philippines); RMNH.MOL.158334; ZMA.MOLL.320233; RMNH.MOL.158332; ZMA.MOLL.320234; ZMA.MOLL.155203; ZMA.MOLL.320232; RMNH.MOL.158331; ZMA.MOLL.320230; ZMA.MOLL.320237; RMNH.MOL.158352; ZMA.MOLL.77115; ZMA.MOLL.320236; RMNH.MOL.158341; ZMA.MOLL.202521; RMNH.MOL.158333; RMNH.MOL.158345; ZMA.MOLL.320229; RMNH.MOL.158342; RMNH.MOL.158351; RMNH.MOL.158336; RMNH.MOL.158337; RMNH.MOL.158350; ZMA.MOLL.105085.2; ZMA.MOLL.320231; ZMA.MOLL.320238; RMNH.MOL.158344; RMNH.MOL.158347; ZMA.MOLL.320235; RMNH.MOL.158339; RMNH.MOL.158340; RMNH.MOL.158348; RMNH.MOL.158349; RMNH.MOL.158335; RMNH.MOL.158338; RMNH.MOL.158343; RMNH.MOL.158346; RMNH.MOL.182142; RMNH.MOL.182142.1.

Tectarius grandinatus: AMD H 37.5 mm from Aitutaki, Cook Islands; ZMA.MOLL.99766. French Polynesia, Tahiti, ex.coll. Ph. Dautzenberg. H 26.03 W 21.34; ZMA.MOLL.320004. No reliable data. Ex. Coll. Schepman. H 29.95 W20.65; ZMA.MOLL.320005. Fuji Islands. H. 26.99 W 18.08; ZMA.MOLL.320002. Lord Hood Islands, 3x. H 33.12 W 22.41 & H 28.29 W 20.02 & H 28.42 W 21.9. *Tectarius rusticus*: ZMA.MOLL.202522, 4x. Broome, West Australia. Ex. Coll. Piet Hessel no 5187. Bought from Perth Shell Distributors; ZMA.MOLL.320003, 1x, New Zealand (?), H 36.9 mm

Tectarius pagodus (Linnaeus, 1758)

1758 *Turbo pagodus* Linnaeus, p. 762; refers to Argenville, pl. H, fig. A "Pagodus" [lectotype figure]; (type-locality,

O. Asiatico, restricted to Amboina, Moluccas (Rosewater, 1972: 519)).

2005 *Tectarius pagodus* (Linnaeus, 1758) – Dharma: 94, pl. 22 fig. 19 (Nusa Tenggara Islands).

2008 *Tectarius pagodus* (Linnaeus, 1758) – Poppe: 474, pl. 182 fig. 12 (Polillo, Philippines)

1986 *Tectarius* (*Tectarius*) *pagodus* (Linné, 1758) – Springsteen & Leobrera: 30, pl. 3 fig. 15 (Samar, Philippines).

1972 *Tectarius pagodus* Linné – Hinton: 2, pl.1 fig. 18 (Trobriands Islands, Papua New Guinea).

1972 *Tectarius pagodus* (Linnaeus, 1758) – Cernohorsky: 57, pl 12 fig. 15.

Synonyms

1822 *Monodonta bicolor* Lamarck, p. 31 (no locality); holotype in MHNG 1096/19, H 54 mm W 38.2 mm.

1840 *Pagodella major* Swainson, p. 351 (no locality given); refers to Chemnitz, pl. 163, figs. 1541, 1542 (specimen figured is lectotype, possibly in Copenhagen Museum fide Rosewater, 1972: 520)).

1850 *Pagodus verus* J. E. Gray, p. 78; refers to *Trochus pagodus* in Quoy and Gaimard, 1833-1834,: 269, plate 62, figs. 1-4 = *Monodonta pagode* Lamarck.

Diagnoses

Shell reaching 65 mm, and sometimes even up to 80 mm, in height, squatty conical, solid, imperforate, and sculptured on the body whorl with 2 carinate rows of usually thick, straightly projecting or slightly upturned spines, between which spiral cords are roughly produced and the shell surface often thrown into oblique waves. Overall external color yellowish to grayish white, with no discernible pattern; in young specimens dark-brown spiral lines may be present externally or within aperture; aperture usually yellowish brown, its edge white. Base distinctly flattened in young to subadult, sculptured spirally with nodulose cords extending into aperture; base separated from upper part of body whorl by one of the rows of spines at periphery. Base convex in adult individuals. Whorls 5-8, flat-sided, excepting spines. Length of spire usually greater than half the length of shell. Spire nearly straight sided. Aperture broadly rounded; outer lip thickly produced in adult individuals, strongly plicate within; plicae not reaching edge of aperture; inner lip smooth, white posteriorly, but forming a prominent bulge (ca. 1 mm) at base of columella. Suture somewhat obscure, overhung by spines of secondary spiral row of succeeding whorl. Outstanding sculptural feature is the mid whorl spinose spiral line which has one also below at the body whorl, with typically form 9-12 antero-posteriorly flattened, triangularly-shaped spines. Only the last 6-7 rows of spines lose the flatness. Surface of shell at the base of spines raised to form oblique fold often reaching to suture. Secondary spiral sculpture of raised, roughened spiral cords, covered with multiple beads, aligned in the angle of the aperture. Operculum large (average about 16 mm. diameter) thin, brown, circular, corneous, paucispiral, nucleus about central. Periostracum not evident. Nuclear whorls worn off. The mid whorl spiral line begins at about second post nuclear whorl; carina becoming spinose almost immediately.

Habitat

The normal habitat of the species is on cliffs above the sea. As there is no evidence that the species is ovoviviparous, there must be a periodic migration to the sea for breeding purposes, although such a phenomenon has not been reported.

Another question arising from the high shore habitat of these nominally marine snails concerns their food. Rumphius (1705) early suggested that they feed upon the cliffs where they live. Examination of some fecal pellets of this species revealed the presence of considerable debris and what appeared to be plant cells. It is quite likely that *T. pagodus* feeds on plant life such as algae and lichens growing on the sea cliffs. The radula is extremely long which may denote such a browsing manner of feeding, the extra length possibly being required because aerial feeding without lubrication from sea water causes a rapid wearing of the teeth (see Quoy and Gaimard, Astrolabe, pl. 62, fig. 1).

"...these animals suck their food from the briny moisture of the cliffs to which they cling, being unable to endure the water" (Rumphius, 1705, p. 74). Found on vertical limestone cliffs 1-2 meters above high tide line (Moluccas Islands, Indonesia, Rosewater 1970, p.518). The habitat is confirmed by Jeroen Goud, curator in NBC and collaborator on expeditions in Indonesia (personal communication with first author, September 2020).

Distribution

From the Philippines, through the Western Pacific Arc to the Solomon Islands. Almost the whole of Indonesian coasts, but predominantly in the eastern region (see Figure 3). Reported from Taiwan (Lee & Chao, 2004) and also known from India and Sri Lanka, northern Indian Ocean (AMD).

Variability

In literature the maximum size is about 62 mm in height (Rosewater, 1972: 518). However, we have seen specimens that get much bigger in size (see Figure 2). This is a very variable species and it could be a cryptic species, that is that *T. pagodus* might be several closely related species. Most specimens originating from the Philippines and Indonesia are often a lot broader than high and have a 'crown' on the shoulder on the spire whorls of connected upturned spirally flattened spines. Also, the base is often whitish in colour while the whorls on the spire are of an orange-brownish colour. These are herein recognized as immature examples of this species. Examples with a convex base with the normal scale color are herein referred to as fully adult specimens. A form is known from the Philippines with less accentuated spines on the crowns and with a third spiral line, but not so much developed. This form awaits further study. The most spiny form is the form of the type (Argenville, pl. H, fig. A "Pagodus").

Remarks

Monodonta bicolor Lamarck, 1822 is generally treated as a synonym of *T. pagodus*. The translation (by first author) of the French comment after the Latin description reads: "My Cabinet. It is the only one that we know of this kind of which the truncation of the columella is poor. Awaits further study. Diam. from the base, 17 lines; same height". The old measure of 'Ligne' is a French unit of length, roughly equal to 2.25 mm (0.089 in), So this specimen = 38,25 mm high and broad. The photos in Rosewater (1972: 518, plate 396 fig 2 and 3) show the supposed "holotype" with measurements of H 54 mm and W 38.2 mm. So the base size is in conformity but the height is different. It could be the Lamarck shell and should be referred to as lectotype. The depicted shell has a rather worn spire and the double rows with spines are visible, so provisionally we agree with the synonymizing. It is clearly not the new species described herein.

Pagodella major Swainson, 1840 is based on Chemnitz pl. 163 fig. 1541 and 1542. These are clearly what we understand as *T. pagodus*. Page 38: "Die pagoda". On page 40: "Meiner exemplare, die ich von dieser nicht eben gemeinen, sondern ziemlich seltenen Schnecke bezitze, … Die Pagodeschnecken werden an den Felsen deh den moluckichen Inseln gefunden". Translated (by the first author): "My specimens, which I own from this not common, but rather rare snail … The pagoda snails are found on the rocks of the Moluccan islands". Though Swainson does not give a locality, Chemnitz apparently does.

Studied material

T. pagodus: : ca 35 examples in our private collections from various locality. ZMA.MOLL.207260; RMNH.MOL.158209; RMNH.MOL.158216; RMNH.MOL.158223; ZMA.MOLL.99831; ZMA.MOLL.90503; RMNH.MOL.158208; ZMA.MOLL.77113; ZMA.MOLL.320204; RMNH.MOL.158205; RMNH.MOL.158213; RMNH.MOL.158220; ZMA.MOLL.320205; ZMA.MOLL.320227; ZMA.MOLL.99832; RMNH.MOL.158207; RMNH.MOL.158212; RMNH.MOL.158219; ZMA.MOLL.320199; RMNH.MOL.158211; RMNH.MOL.158215; ZMA.MOLL.77114; ZMA.MOLL.320201; ZMA.MOLL.320202; RMNH.MOL.158217; RMNH.MOL.158222; RMNH.MOL.158206; RMNH.MOL.158210; RMNH.MOL.158214; ZMA.MOLL.77117; ZMA.MOLL.320203; RMNH.MOL.158204; RMNH.MOL.158221; ZMA.MOLL.30120; ZMA.MOLL.320198; ZMA.MOLL.320206; ZMA.MOLL.320207; ZMA.MOLL.99830; ZMA.MOLL.189186; RMNH.MOL.324297; ZMA.MOLL.320200; ZMA.MOLL.320226; RMNH.MOL.343534; RMNH.MOL.343535; RMNH.MOL.158218. Most of these lots have no (exact) locality data besides Indonesia and/or Moluccas.

Conclusion

Analysis of morphological data show high variability among large *Tectarius* species. Based on the results of this study, we describe one new species from Java. Other variability within *Tectarius pagodus* still awaits further research in the future.

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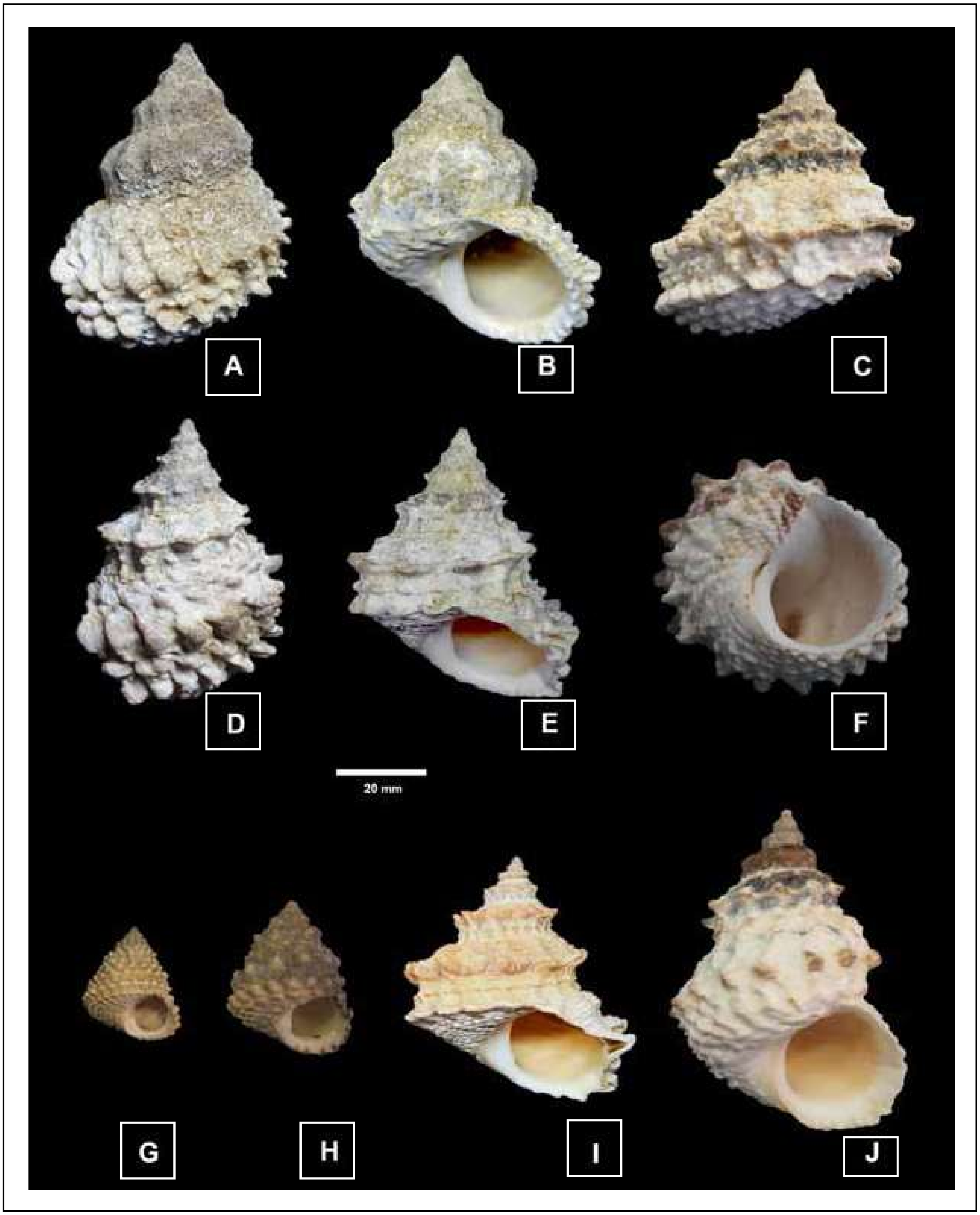

Figure 1.

A-F Tectarius padmiae sp. nov., Malang, South of Java. **A, B** holotype, H 69.5 mm W 54 mm (MZB), **C, F** paratype 1, H 68 mm W 51.3 mm (NBC), **D, E** paratype 2, H 66 mm W 51.5 mm (ARN), **G** *Tectarius grandinatus* (Gmelin, 1791), Tahiti, French Polynesia, H 26,3 mm W 21.1 mm (NBC, ZMA.MOLL.99766), **H** *Tectarius tectumpersicum* (Linnaeus, 1758), West New Guinea H 34.45 mm W 27.95 mm (AMD), **I** *Tectarius pagodus* (Linnaeus, 1758), Malang, South of Java, H 57.5 mm W 46.5 mm (ARN), **J** *Tectarius cf. padmiae*, Moluccas, Indonesia, H 74,53 mm W 52.5 mm (NBC, ZMA.MOLL.320198).

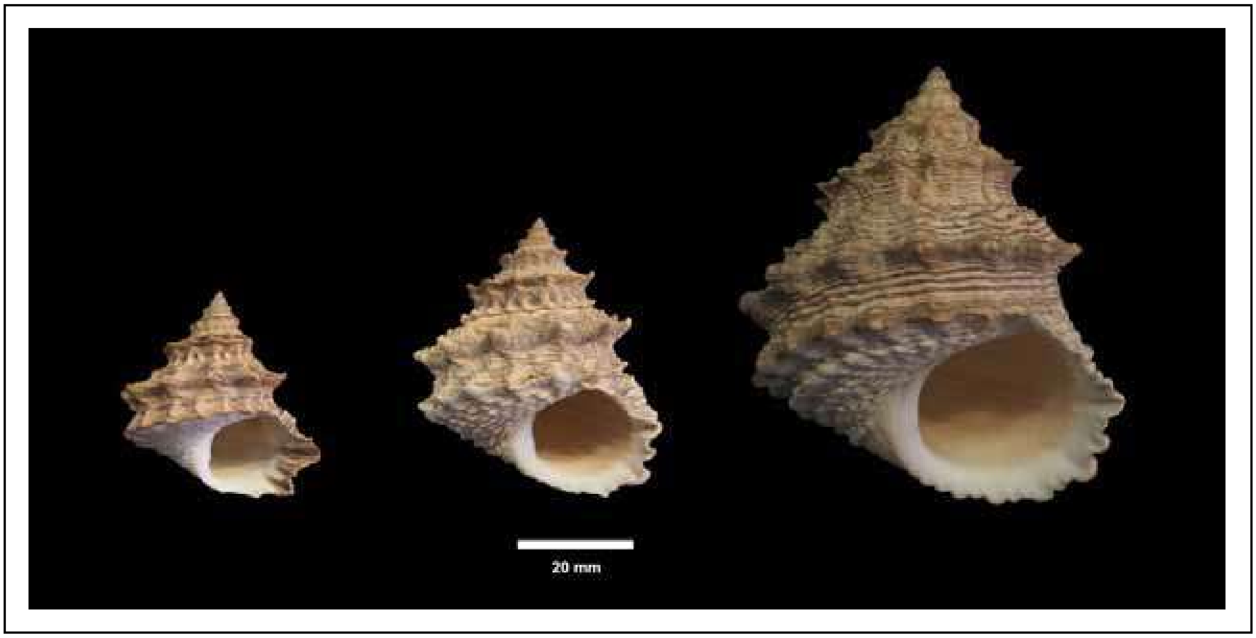

Figure 2.
Growth phases of *Tectarius pagodus* (Linnaeus, 1758), Moluccas, Indonesia, Schepman collection (1920), NBC, ZMA.MOLL.320202. Small: H 38.86 mm W 30.77 mm, Medium: H 50.12 mm W 36.0 mm, Large: H 78.75 mm W 58.01 mm

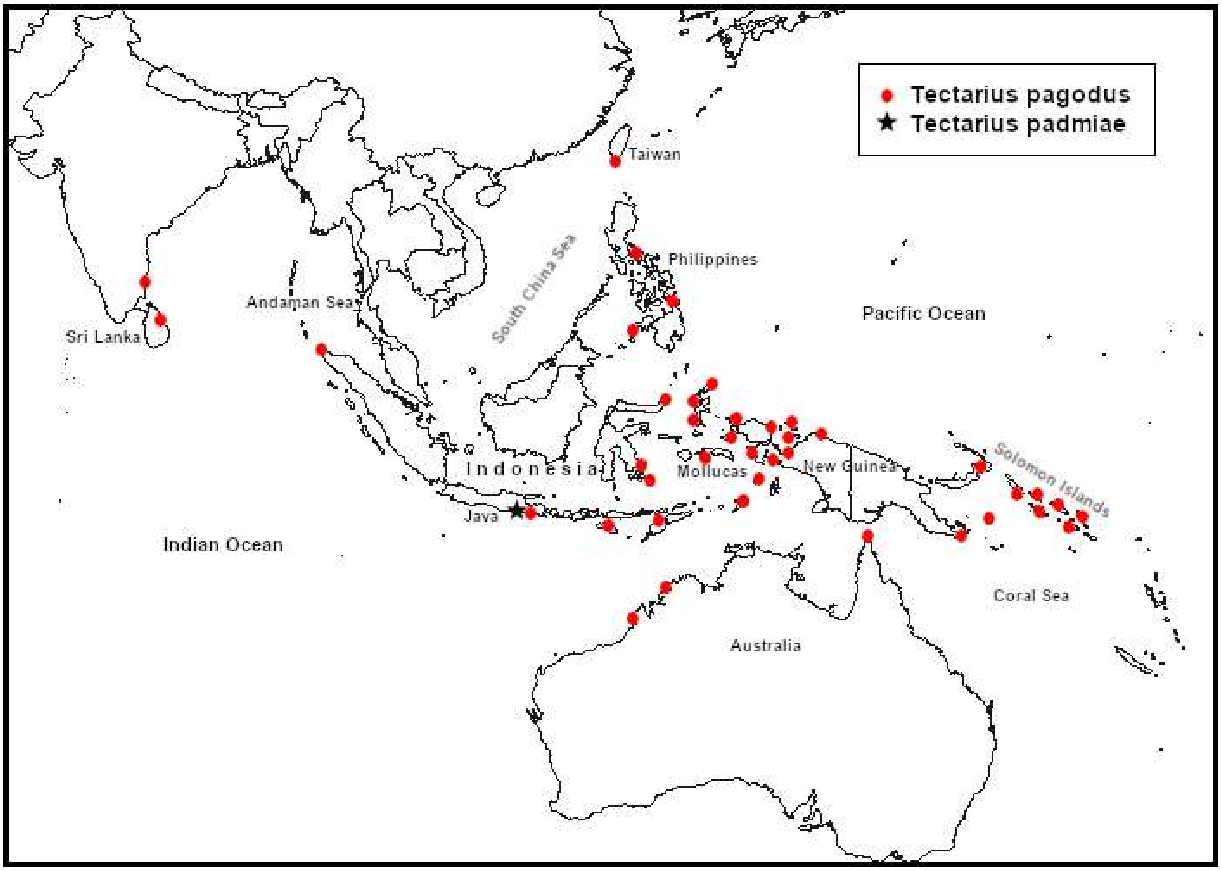

Figure 3.
Geographic distribution of *Tectarius padmiae* sp. nov. and *Tectarius pagodus* (Linnaeus, 1758). The locations for *T. pagodus* are derived from our personal collections and literature.